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## (54) Mobile station and method for monitoring of neighboring cells during reception of code division multiple access (CDMA) paging in a cellular mobile communications network

(57) A mobile station and method for monitoring of neighboring cells during reception of Code Division Multiple Access (CDMA) paging in a cellular mobile communications system. During the reception of the paging information in a serving cell of a CDMA system, at least a subset of the rake fingers in the rake receiver of the mobile station which are not used for the reception of the paging information is used for monitoring of neighboring cells. During at least a portion of the paging reception period when paging information is not being received, at least a portion of the receiver system is used for the monitoring of neighboring cells.

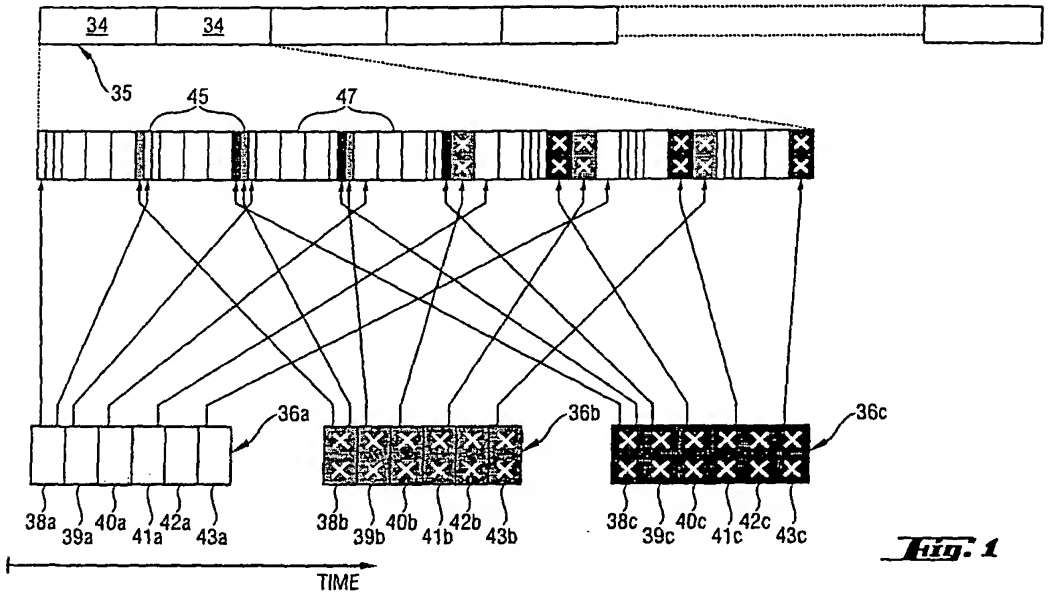


Fig. 1

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## Description

### Background

[0001] The present invention relates to mobile communication systems in general, and, more specifically, to a mobile station and method for monitoring of neighboring cells during reception of Code Division Multiple Access (CDMA) system paging in a cellular mobile communications system.

[0002] A mobile station, or terminal, of a mobile communications network in the idle mode must be able to receive incoming calls and be ready to support outgoing calls while moving between network cells. These goals are achieved by means of the following activities:

1. Reception of paging information
2. Monitoring of neighboring cells

[0003] Both reception of paging information and monitoring of neighboring cells require the mobile station to be powered-up to a standby state. When the mobile station has nothing to do it enters a powered-down state to conserve battery power and extend the standby time.

[0004] Reception of paging information typically requires the mobile station to power-up and remain in a standby state while it receives a series of designated paging parts contained in paging blocks, or portions of blocks. Among other things, the paging information notifies the mobile unit of any incoming calls. There may typically be time periods, or slots, between reception of relevant paging information parts when the mobile station is not receiving paging information. During these intervening time slots, the mobile station must remain in a powered-up state because there is typically insufficient time for the mobile station to power down and power back up again in time to receive the next relevant paging information part. A typical mobile station may require, for example, 5 ms to power up and stabilize its radio receiver.

[0005] Monitoring of neighboring cells is performed to effect mobility between cells of the network. A mobile station in the idle state needs to maintain the best possible conditions for call set-up. Toward this end, the mobile station collects information about surrounding, or neighboring, cells contained in network broadcast information. Based on this information, the mobile station regularly measures quantities which characterize the reception quality of the neighboring cells. This measurement activity is known as neighboring cell monitoring. When a neighboring cell is found more suitable than the serving cell the mobile station performs cell reselection. These measure quantities may include: downlink received signal power, downlink signal-to-interference ratio, and downlink path loss.

[0006] As noted above, performing neighboring cell monitoring requires the mobile station to be powered-up. Mobile communications system specifications may not set forth how these idle mode neighboring cell measurements can be performed in an efficient way with respect to power consumption.

### Advantages of the Invention

[0007] The present invention provides a mobile station for a cellular mobile communications network, the mobile station including a rake receiver having a plurality of rake fingers, the mobile station operating in a Code Division Multiple Access system in a frequency band and receiving paging information during a portion of a paging reception period, characterized in that during the reception of the paging information, at least a subset of the rake fingers not used for the reception of the paging information are used for monitoring of neighboring cells.

[0008] The present invention also provides a mobile station for a cellular mobile communications network, the mobile station including a receiver system, the receiver system including a rake receiver having a plurality of rake fingers, the mobile station operating in a Code Division Multiple Access system in a frequency band and receiving paging information during a portion of a paging reception period, characterized in that during at least a portion of the paging reception period when paging information is not being received, at least a portion of the receiver system is used for monitoring of neighboring cells.

[0009] The present invention also provides an article comprising a storage medium, the storage medium having a set of instructions, the set of instructions being capable of being executed by at least one processor to implement a method for monitoring of neighboring cells by a mobile station of a cellular mobile communications network, the mobile station including a rake receiver having a plurality of rake fingers, the mobile station operating in a Code Division Multiple Access system in a frequency band and receiving paging information during a portion of a paging reception period, characterized in that during the reception of the paging information, at least a subset of rake fingers not used for the reception of the paging information are used for monitoring of neighboring cells.

[0010] The present invention also provides a method for monitoring of neighboring cells by a mobile station of a cellular mobile communications network, the mobile station including a rake receiver having a plurality of rake fingers, the mobile station operating in a Code Division Multiple Access system in a frequency band and receiving paging information during a paging reception period, characterized in that during the reception of the paging information at least a subset of rake fingers not used for the reception of the paging information are used for monitoring of neighboring cells.

[0011] In one embodiment of the present invention, neighboring cells in a frequency band different than that of the serving cell are monitoring during at least a portion of the regular reception of paging when paging informa-

tion is not being received.

**[0012]** In another embodiment of the present invention, neighboring cells belonging to a system different than that of the serving cell are monitored during regular reception of paging between reception of relevant paging parts. For this embodiment, the mobile station must be a multi-mode terminal.

**[0013]** According to the present invention, neighboring cell monitoring may be performed in one power-up and power-down cycle while the mobile station is engaged in a periodic paging reception cycle. Monitoring neighboring cells during paging block reception reduces the total power-up time and thereby increases the maximum standby time of the mobile station.

**[0014]** Further advantages of the present invention will become apparent from the claims and the description below, based on the drawings, in which:

Drawings

**[0015]**

Fig. 1 is a schematic diagram showing the arrangement of paging blocks in time slots in a UMTS paging channel;

Fig. 2 is a schematic diagram of a mobile station according to the present invention and showing portions of three network cells:

Fig. 3 is a schematic diagram showing rake receiver behavior for a sequence of UMTS paging channel time slots in accordance with an embodiment of the invention for monitoring neighboring cells in the same band as the serving cell when the PI parts indicate no relevant information in MUI parts;

Fig. 4 is a schematic diagram showing rake receiver behavior for a sequence of UMTS paging channel time slots in accordance with the embodiment of the invention depicted in Fig. 3 when the PI parts indicate there is relevant information in MUI parts;

Fig. 5 is a schematic diagram showing rake receiver behavior for a sequence of UMTS paging channel time slots in accordance with an embodiment of the invention for monitoring neighboring cells in a different band from the serving cell when the PI parts indicate no relevant information in MUI parts;

Fig. 6 is a schematic diagram showing rake receiver behavior for a sequence of UMTS paging channel time slots in accordance with the embodiment of the invention depicted in Fig. 5 when the PI parts indicate there is relevant information in MUI parts;

Fig. 7 is a schematic diagram showing rake receiver behavior for a sequence of UMTS paging channel time slots in accordance with an embodiment of the invention for monitoring neighboring cells in a different system from the serving cell when the PI parts indicate no relevant information in MUI parts; and

Fig. 8 is a schematic diagram showing rake receiver behavior for a sequence of UMTS paging channel time slots in accordance with the embodiment of the invention depicted in Fig. 7 when the PI parts indicate there is relevant information in MUI parts.

Description

**[0016]** The present invention will now be described with particular reference to exemplary embodiments in the context of a Universal Mobile Telephone System/ Frequency Division Duplex (UMTS/FDD) mobile terminal operating in a Third Generation Partnership Project (3GPP) mobile communications system.

**[0017]** A UMTS/FDD mobile terminal receives, decodes, codes and sends messages in a Code Division Multiple Access (CDMA) environment. As is known, reception in a UMTS mobile terminal is performed using a rake receiver having multiple fingers which may be allocated in groups to receive disparate signals simultaneously. See Glisic, Savo and Branka Vucetic, Spread Spectrum CDMA Systems for Wireless Communications, Artech House Publishers, 1997.

**[0018]** Reception of paging information may be performed as follows:

**[0019]** Referring to Fig. 1, in idle mode a UMTS mobile station powers-up and listens periodically to designated paging block [36a-c] repeated in PCH frames [34] on the PCH (paging channel) transmitted on the Secondary CCPCH (Common Control Physical Channel) [35]. Each paging block carries six information parts: two Paging Indication (PI) parts [38a-c] and [39a-c], respectively, for indicating whether any paging messages for that mobile station are present, and four Mobile User Identifier (MUI) parts, [40a-c], [41a-c], [42a-c] and [43a-c], respectively, for indicating the subscriber identity and carrying the actual paging message. The paging blocks are mapped to Secondary CCCPCH [35] so that the PI parts [38a-c] and [39a-c] and MUI parts [40a-c], [41a-c], [42a-c] and [43a-c] are distributed into disparate time slots or time slot portions [45] in PCH frames [34], as shown in Fig. 1. This distribution of PI and MUI parts in time results in interleaved time slots or time slot portions [47] with information of no relevance to the particular mobile station, such as paging blocks designated for other mobile stations, empty time slots, etc. See 3GPP Radio Access Network (RAN), S1.11 Transport channel and physical channels, version 0.0.0 (1999-02).

**[0020]** In each block, the PI parts are transmitted ahead of the MUI parts. Upon receiving a portion of a paging block, the mobile station first examines the PI parts. If the PI parts indicate that the MUI parts carry

paging information, the mobile station is required to receive and examine one or more of the 4 MUI parts. Otherwise, the mobile station may skip the MUI parts. Once the mobile station has completed each periodic listening cycle, or paging reception period, it typically powers-down.

**[0021]** Referring to Fig. 2, UMTS mobile station [102] includes processor [110] and rake receiver [104] having a plurality of rake fingers [108]. Rake receiver [104] is a part of receiver system [103]. Where mobile station [102] is a multi-mode terminal having a receiver system capable of tuning between signals of two different systems, receiver system [103] may include one or more other receivers or receiver subsystems (not shown). Mobile station [102] may be a multi-mode mobile station, capable of operating, for example in a Global System for Mobile Telecommunications (GSM) system as well as a UMTS system. Mobile station [102] operates in serving cell [112] and powers up to receives paging information 118 in the cell during a paging reception period. Paging information [118] is paging information designated for the mobile station, the information being spread out in time in a discontinuous fashion, as described above. Adjacent to cell [112] are neighboring cells [114] and [116]. During the reception of paging information [118], a subset of rake fingers [108] not being used for the reception of the paging information may be used for monitoring of neighboring cell [114] and/or neighboring cell [116], and/or any additional neighboring cells. Also, during times in a paging reception period between reception of paging information, while the rake receiver remains in a powered-up state but not receiving paging information, all or a subset of all rake fingers may be used for monitoring of the neighboring cells. After receiving all relevant paging information needed, the mobile station powers down.

**[0022]** Three exemplary variants, or embodiments, of the present invention are described below:

Variant 1:

**[0023]** Referring additionally to Figs. 3 and 4, mobile station [102] may monitor UMTS/FDD carriers in same band as serving cell [112] during a paging reception period, both during reception of paging information [118] and in time slots or time slot portions between reception of paging information. Fig. 3 depicts the situation in which the PI parts of paging information [118] indicate no relevant information for mobile station [102] in the MUI parts of the paging block. UMTS frame [50] has time slots [1]-[5], with paging information [52a] and [52b] being received in portions of time slots [1] and [5], respectively, and no designated paging information being received in time slots [2]-[4] and remaining portions of time slots [1] and [5]. During time periods [56a] and [56b], corresponding to portions of time slots [1] and [5], respectively, rake receiver [104] receives paging information [52a] and [52b]. During time periods [56a] and [56b], all available rake fingers [108] not being used to receive the paging information are preferably allocated to monitor neighboring cells [114] and [116] by measuring signals from these cells in the same frequency band as serving cell [112]. During time period [58], corresponding to time slots [2]-[4] and portions of time slots [1] and [5], all rake fingers [108] are used to monitor the neighboring cells. Alternatively, during one, some, or all of time periods [56a], [56b] and [58], a subset of available rake fingers are used to monitor neighboring cells. By "available" rake fingers is herein meant rake fingers not allocated to other receiver functions. Generally, the speed of the monitoring process is a function of the number of rake fingers allocated to monitoring. Mobile station [102] powers up during time period [60], before time slot [1], remains in a powered-up state during time period [62], for time slots [1]-[5], then powers down during time period [64] since paging information [52a] and [52b] has indicated that there is no relevant information for the mobile station.

**[0024]** Fig. 4 depicts the situation in which the PI parts of paging information [118] indicate that there is relevant information for mobile station [102] in the MUI parts of the paging block. The element numbering mirrors that of Fig. 3. In this case, the mobile station remains in a powered-up state from time slot [1] through time slot [24] so that it can receive paging information [52a-f], in time slots [1], [5], [9], [14]. [19] and [24]. The mobile station must remain in a powered-up state because, as embodied herein, and as is typical, the mobile station is not capable of powering down and up in the relatively short time span (less than .625 msec in a UMTS system) between each set of time slots [1] and [5], [5] and [9], [9] and [14], [14] and [19], and [19] and [24]. During time periods [56a-f], corresponding to respective portions of time slots [1], [5], [9], [14], [19] and [24], rake receiver [104] receives paging information [52a-f]. Similar to the situation described with reference to Fig. 3, during time periods [56a-f] at least a subset of available rake fingers [108] not being used to receive the paging information is allocated to monitor neighboring cells [114] and [116] by measuring signals from these cells in the same frequency band as serving cell [112]. During time periods [58a-f], corresponding to the portions of time slots [1]-[24] outside of time periods [56a-f], at least a subset of available rake fingers [108] are preferably used to monitor the neighboring cells. Preferably, all available rake fingers [108] are used to monitor neighboring cells time periods [58a-f]. Mobile station [102] powers up before time slot [1], remains in a powered-up state for time slots [1]-[24], then powers down after having received all relevant paging information needed.

Variant 2:

**[0025]** Referring additionally to Figs. 5 and 6, mobile station [102] may monitor UMTS/FDD carriers in a frequency band different from that of serving cell [112] dur-